The upper limits for measurement are the actual ground surface at the time of starting work. The lower limits for measurement are established by the plans or as directed in writing.

No measurement is made of the following excavation:

(A) Mud, muck or similar semi-solid material which can be drained away or pumped without the use of a jet or nozzle.

(B) Excavation before the Engineer makes measurements of the undisturbed ground.

(C) Excavation that is within the pay limits of other excavation.

(D) Excavation that is outside of the limits shown in the plans or as directed in writing.

Where the item *Channel Excavation* is not included in the contract, no measurement or payment is made of any channel excavation, as payment at the contract unit or lump sum price for the various items in the contract will be full compensation for the work covered by this section.

This price and payment will be full compensation for all items required to complete channel excavation.

Payment will be made under:

Pay Item	Pay Unit
Channel Excavation	Cubic Yard

SECTION 420
CONCRETE STRUCTURES

420-1 DESCRIPTION

Construct cast-in-place concrete structures and the cast-in-place concrete portions of composite structures in conformity with the lines, grades and dimensions shown in the contract. Furnish and place concrete, joint filler and sealer, curing agents, epoxy protective coating, deck drains, expansion anchors and any other material; erect and remove all falsework and forms; protect concrete in wind, rain, low humidity, high temperatures or other unfavorable weather; construct joints and weep holes; finish and cure concrete; protect concrete from rust stains; and groove bridge floors. For reinforced concrete deck slabs, in addition to the above, furnish and place reinforcing steel and bridge scuppers; and design, furnish, erect and remove all bridge deck forms including any appurtenances required by the Engineer to stabilize exterior girders during overhang construction.

420-2 MATERIALS

Refer to Division 10.

Item	Section
Calcium Nitrite Corrosion Inhibitor	1000-4(K)
Curing Agents	1026
Deck Drains	1054-1
Epoxy Protective Coating	1081
Expansion Anchors	1074-2
Joint Fillers	1028-1
Joint Sealers	1028
Metal Stay-in-Place Forms	1074-12
Portland Cement Concrete	1000
Reinforcing Steel	1070

420-3 FALSEWORK AND FORMS

(A) General

Submit 8 sets of detailed drawings for falsework or forms for bridge superstructure and other components as required by the contract for review, comments and acceptance before beginning construction of the falsework or forms. This review does not relieve the Contractor of full responsibility for the safety, alignment, quality or finish of the work.

Design falsework and forms to carry the full loads upon them, including a dead load of 150 lb/cf for concrete, loads caused by equipment and personnel, and for lateral pressures resulting from rate of pours, setting times and effects of vibration on the concrete, so the finished concrete surface conforms to the proper dimensions and contours and has an even appearance.

Use lumber and other material for forms and falsework that is sound and in good condition.

Set falsework and forms to give the correct elevation shown on the drawings making proper allowance for shrinkage, deflections and settlement, and maintain true to lines and grades designated until the concrete sufficiently hardens.

Where falsework or forms appear to be unsatisfactorily built in any respect either before or during placing of concrete, the Engineer will order the work stopped until the defects are acceptably corrected.

Keep the falsework and forms in place after placing of concrete for the periods specified in Article 420-16. Remove falsework and forms in an acceptable manner. Do not leave forms or falsework permanently in place without written approval.

Provide a means, satisfactory to the Engineer, to check any settlement or deflection that may occur during the placing of concrete in the various portions of the work.

(B) Falsework

Build falsework on foundations of sufficient strength to carry the applied loads without appreciable settlement. Support falsework that cannot be founded on solid footings on ample falsework piling.

Use an acceptable method to compensate for shrinkage, deflection and settlement. Use jacks to readily effect adjustment, if necessary, before or during placing of concrete, if required by the Engineer.

(C) Forms

(1) General

Use forms made of wood or steel except where other materials are specified by the contract or accepted by the Engineer.

(2) Wood Forms

Build forms mortar-tight of material sufficient in strength with ample studding, walling and bracing to effectively prevent any appreciable horizontal and vertical deflection.

Provide forms with interior dimensions such that the finished concrete is of the form and dimensions shown in the plans.

Line forms, except for surfaces permanently in contact with earth fill, with plywood or other approved material. Provide a lining with a smooth and uniform texture and of such thickness and rigidity that a concrete surface of uniform texture and even appearance results. Provide joints between form liners that are mortar tight and even and maintain to prevent the opening of joints due to the shrinkage of the lumber.

Fillet forms at all sharp corners unless otherwise noted in the plans. Mill wood chamfer strips from straight grained lumber and surface on all sides.

Give forms for all projections a bevel or draft to insure easy removal.

At all times, maintain the shape, strength, rigidity, watertightness and surface smoothness of reused forms. Resize any warped or bulged lumber before reusing. Do not reuse any forms that are unsatisfactory in any respect. Do not use plywood sheets showing torn grain, worn edges, patches, holes from previous use or other defects that impair the texture of concrete surfaces exposed to view.

Maintain an acceptable alignment and no broken edges on all chamfer strips.

Thoroughly clean forms previously used of all dirt, mortar and foreign material before reusing. Before placing concrete in forms to be removed, thoroughly coat all inside surfaces of the forms with commercial quality form oil or other equivalent coating which permits the ready release of the forms and does not discolor the concrete.

Construct or install metal spacers or anchorages, required within the forms for their support or to hold them in correct alignment and location, in such a way that the metal work can be removed to a depth of at least 1" from the exposed surface of the concrete without injury to such surface by spalling or otherwise. Limit the diameter to not greater than 1.5 times its depth for the recess formed in the concrete. Cut back all such metal devices in exposed surfaces, upon removal of the forms, to a depth of at least 1" from the face of the concrete. Carefully fill cavities produced by the removal of metal devices with cement mortar of the same mix used in the body of the work immediately upon removal of the forms, and leave the surface smooth, even and as nearly uniform in color as possible. As an option, break off flush with the concrete surface those metal devices with cross-sectional area not exceeding 0.05 sq.in. on surfaces permanently in contact with earth fill.

Do not weld metal devices to either reinforcing steel or structural steel that is a permanent part of the structure without written approval.

(3) Steel Forms

Apply Subarticle 420-3(C)(2) in regards to design, mortar tightness, filleted corners, beveled projections, bracing, alignment, texture and evenness of appearance of the resulting concrete surface, removal, re-use and oiling to steel forms. Use steel for forms of such thickness that the forms remain true to shape. Counter-sink bolt and rivet heads. Design clamps, pins or other connecting devices to hold the forms rigidly together and allow removal without injury to the concrete. Do not use steel forms that do not present a smooth surface or line up properly. Exercise care to keep steel forms free from rust, grease or other foreign matter that will tend to discolor the concrete.

(D) Forms for Concrete Bridge Decks

In addition to Subarticles 420-3(C)(1) through 420-3(C)(3), the following requirements apply to falsework and forms used to construct reinforced concrete bridge decks on girders. Furnish all materials, labor, equipment and incidentals necessary for the proper installation of falsework and forms for concrete bridge deck slabs.

For prestressed girder spans, the plans for the concrete deck slab are detailed for the use of a cast in place slab using either precast prestressed concrete panels or fabricated metal stay in place forms. Optionally, construct a cast in place slab using removable forms.

For structural steel spans, plans for the concrete deck slab are detailed for the use of metal stay in place forms. Optionally, construct a cast in place slab using removable forms. Do not use precast prestressed concrete panels on structural steel spans.

If using a form system other than that detailed in the plans, do so at no additional cost to the Department. Changes in slab design to accommodate the use of optional forms are the responsibility of the Contractor. Submit these changes for review and approval. Before using optional forms, submit 2 sets of prints of detailed checked plans of the system and checked design calculations for the composite slab complying to the latest *AASHTO LRFD Bridge Construction Specifications, AASHTO LRFD Bridge Design Specifications* and *Highway Design Branch Structure Design Manual*. After the drawings are reviewed and, if necessary, the corrections made, submit reproducible drawings of the deck system to become the revised plans. Ensure that the size of the sheets used for the drawings is 22" x 34". Ensure that the plans and design calculations are checked and sealed by an engineer licensed by the State of North Carolina.

Where reinforced concrete deck slab with sand lightweight concrete is required by the contract, do not use precast prestressed concrete panels.

Unless otherwise shown in the plans, use the same forming system for all of the same type superstructure spans within the bridge. Construct the slab overhang from the exterior girder to the outside edge of superstructure using removable forms.

(1) Precast Prestressed Concrete Panels

Prestressed concrete panels are subject to the requirements for prestressed concrete members as specified in Section 1078, the plans and the *Standard Specifications*.

Design prestressed panels subject to review by the Engineer. Before using prestressed panels, submit 7 sets, including one reproducible set, of detailed plans of the panels for review. Submit with the checked plans one set of checked design calculations for the panels complying with the latest *AASHTO LRFD Bridge Design Specifications*, requirements detailed herein and the plans. Ensure the plans and design calculations are checked and sealed by an engineer licensed by the State of North Carolina. If corrections to the drawings are necessary, submit one set of corrected reproducible drawings. Use a plan sheet size of 22" x 34". The drawings become part of the plans.

Design the prestressed concrete panels in accordance with the following criteria:

(a) Design details to provide a mating surface joint or a draft not exceeding 1/8" resulting in a joint that is closed at the top and no more than 1/4" open at bottom of panel. Detail the joints filled with grout or other methods approved by the Engineer to prevent leakage of the concrete. Place a chamfer or fillet, with a 3/4" horizontal width, along the top edges of the panel parallel with the prestressed girder.

(b) Design panels to support the dead load of the panel, reinforcement, plastic concrete and a 50 lb/sf construction load. Design the panel and slab acting compositely to support design live loads and dead loads acting on the composite section. Include in the design dead load acting on the composite section an additional load of 30 lb/sf for a future asphalt wearing surface. For bridges up to 44 ft in width distribute equally to all deck panels superimposed dead loads for such permanent bridge items as barrier rails, medians or any dead load which is applied after the deck is cast. In the case of bridges over 44 ft wide, distribute these loads equally to the first 2 1/2 panels adjacent to each side of the load.

(c) The design span of the prestressed concrete panel is the clear distance between edges of girders plus 2" measured parallel to the panel edges.

(d) Limit tension in the precompressed tensile zone to 424 psi unless the plans require 0 psi tension.

(2) Fabricated Metal Stay-In-Place Forms

Furnish metal stay-in-place forms with closed tapered ends to form the concrete deck slabs as shown in the plans. Submit 8 copies of complete fabrication and erection drawings for review, comments and acceptance. Indicate on these plans the grade of steel, the physical and section properties for all permanent steel bridge deck form sheets and a clear indication of locations of form supports. Do not fabricate the forming material until drawings are accepted.

When required by the design plans, detail stay-in-place forms with excluder plates to exclude concrete from the valleys in the forms. Foam insulation void fillers may be used in stay-in-place metal forms. Adhesive shall be used on all 3 contacting sides of the foam insulation void fillers rather than on the bottom only. The adhesive shall be compatible with the foam insulation material to not cause decomposition. Duct tape shall not be used to hold the foam insulation in place. Foam insulation shall be placed in one piece across each bay and be trimmed to not extend over the girder. Foam insulation damaged during placement of reinforcing steel shall be replaced.

Design metal stay-in-place forms in accordance with the following criteria:

(a) Accommodate the dead load of the form, reinforcement and the plastic concrete, including the additional weight of concrete due to the deflection of the metal forms, plus 50 lb/sf for construction loads. Do not allow the unit working stress in the steel sheet to exceed 72.5% of the specified minimum yield strength of the material furnished nor 36 ksi.

(b) Limit the horizontal leg of the support angle to 3". Design the support angle as a cantilever.

(c) Limit the deflection under the weight of the forms, the plastic concrete and reinforcement to 1/180 of the form span or 1/2" whichever is less. Do not design for a total loading less than 120 lb/sf.

(d) Base the permissible form camber on the actual dead load condition. Do not use camber to compensate for deflection in excess of the foregoing limits.

(e) The design span of the form sheets is the clear distance between edges of beam or girder flanges minus 2" measured parallel to the form flutes. Design and provide form sheets with a length at least the design span of the forms.

(f) Compute physical design properties in accordance with requirements of the American Iron and Steel Institute *Specification for the Design of Cold-Formed Steel Structural Members* latest published edition.

(g) Provide a minimum concrete cover of 1 1/4" clear above metal stay-in-place form to the bottom mat of reinforcement.

(h) Maintain the plan dimensions of both layers of primary deck reinforcement from the top of the concrete deck.

(i) Do not weld to flanges in tension or to structural steel bridge elements fabricated from non-weldable grades of steel.

(j) Weld metal stay-in-place forms for prestressed concrete girders to embedded clips in the girder flanges. The embedded clips shall be at least 2" x 3" and 2" long. The clips shall be galvanized, 12 gauge ASTM A653 steel and have a 3/4" or 1" diameter hole in the 2" leg. The spacing of the clips shall be 12". All submitted metal stay-in-place form designs shall be able to use the standard size and spacing of the clip described above.

Do not unload or handle fabricated metal stay-in-place forming materials so as to damage or alter the configuration of the forms. Replace damaged materials at no additional cost to the Department.

Store fabricated metal stay-in-place forms that are stored at the project site at least 4" above the ground on platforms, skids or other suitable supports and protect against corrosion and damage from any source.

Install all forms in accordance with detailed fabrication plans submitted to the Engineer for review. Clearly indicate on the fabrication plans the locations where the forms are supported by steel beam flanges subject to tensile stresses. Do not weld to the flanges within these locations. Do not allow form sheets to rest directly on the top of the beam or girder. Securely fasten sheets to form supports with a minimum bearing length of 1" at each end. Center sheets between the form supports. Place form supports in direct contact with the flange of girder or beam. Make all attachments by permissible welds, bolts, clips or other approved means. Weld in accordance with Article 1072-18 except 1/8" fillet welds are permitted.

In the areas where the form sheets lap, securely fasten the form sheets to one another by screws at a maximum spacing of 18". Securely attach the ends of the form sheets to support angles with screws at a maximum spacing of 18".

Where the galvanized coating is damaged, repair in accordance with Article 1076-7. Minor heat discoloration in areas of welds is not damage and does not require the above repair.

Locate transverse construction joints at the bottom of a flute and field drill 1/4" weep holes at not more than 12" on center along the line of the joint.

Use a saw for all cuts. Do not flame cut forms.

(E) Falsework and Forms Over or Adjacent to Traffic

In addition to the applicable sections in Subarticle 420-3(A) through 420-3(D), the following requirements apply to falsework and forms including metal stay-in-place forms and precast concrete deck panels erected over vehicular, pedestrian or railroad traffic or vessel traffic on navigable waterways. It also covers falsework and forms for those parts of a substructure unit constructed within 20 ft of the edge of a travelway or railroad track and more than 25 ft above the ground line at the time of substructure construction.

(1) Submittals

Submit detailed drawings as required by the contract and one set of design calculations for falsework and forms for review and acceptance before beginning construction of the falsework or forms. Ensure the drawings and design calculations are prepared, signed and sealed by an engineer licensed by the State of North Carolina. These submittal requirements apply to all falsework and form systems covered by this section.

(2) Design

Design falsework and forms for the combined effects of dead load and live load and with appropriate safety factors in accordance with this section and the respective design codes of the materials used. Include the weight of concrete, reinforcing steel, forms and falsework in the dead load. Live load includes the actual weight of any equipment the falsework supports, applied as concentrated loads at the points of contact and a uniform load of at least 20 lb/sf applied over the supported area. In addition, apply a line load of 75 lb/ft along the outside edge of deck overhangs.

(3) Inspection

Before the form or falsework system is loaded, inspect the erected falsework and forms and submit a written statement certifying that the erected falsework system complies with the accepted detailed drawings prepared by an engineer licensed by the State of North Carolina. Submit a separate certification for each span, unit or bridge component. Any condition that does not comply with the accepted drawings, or any other condition deemed unsatisfactory by the Engineer, is cause for rejection until corrections are made.

420-4 PLACING CONCRETE

Do not place concrete until the depth of the excavation, character of the foundation material, adequacy of the forms and falsework, placement of reinforcement and other embedded items are inspected and approved. Do not place concrete without the Department's inspector present.

Place concrete in daylight or obtain approval for an adequate lighting system for construction and inspection of the work.

In preparation for the placing of concrete, remove all sawdust, chips and other construction debris and extraneous matter from the interior of forms. Remove hardened concrete and foreign matter from tools, screeds and conveying equipment.

Ensure that the concrete temperature at the time of placement in the forms is at least 50°F and no more than 95°F, except where other temperatures are required by Article 420-7 and 420-14.

Do not use concrete that does not reach its final position in the forms within the time stipulated in Subarticle 1000-4(E).

Thoroughly clean and wet surfaces, other than foundation surfaces, immediately before placing concrete to help bonding to those surfaces.

Regulate the placement of concrete so the pressures caused by the wet concrete do not exceed those used in the design of the forms.

Thoroughly work the external surface of all concrete during the placing with approved tools. During the placing of concrete, take care to use methods of compaction that result in a surface of even texture free from voids, water or air pockets, and that force the coarse aggregate away from the forms to leave a mortar surface.

Place concrete to avoid segregation of the materials and the displacement of the reinforcement.

Equip chutes on steep slopes with baffle boards or provide chutes in short lengths that reverse the direction of movement.

Use all chutes, troughs and pipes made from suitable materials other than aluminum and keep them clean and free from coating of hardened concrete by thoroughly flushing with water after each run. Discharge the water used for flushing clear of the structure.

Confine concrete dropped more than 5 ft by closed chutes or pipes, except in walls of box culverts or retaining walls unless otherwise directed.

Take care to fill each part of the form by depositing the concrete as near to its final position as possible. Work the coarse aggregate back from the forms and around the reinforcement without displacing the bars. After initial set of the concrete, do not jar the forms and do not place strain on the projecting reinforcement or other items embedded in the concrete.

Compact all concrete required to be vibrated with approved high frequency internal vibrators or other approved type of vibrators immediately after depositing concrete in the forms. In all cases, have available at least 2 vibrators in good operating condition and 2 sources of power at the site of any structure in which more than 25 cy of concrete is required. Do not attach or hold the vibrators against the forms or the reinforcing steel. When vibrating concrete containing epoxy coated reinforcing steel, use a vibrator with a protective rubber head as approved by the Engineer. Vibrate with care and avoid displacement of reinforcement, ducts or other embedded elements. Vibrate in the appropriate location, manner and duration to secure maximum consolidation of the concrete without causing segregation of the mortar and coarse aggregate and without causing water to flush to the surface. When placing concrete to a depth in excess of 12" and containing one or more horizontal layers of reinforcing steel, place the concrete in horizontal layers not more than 12" thick. Place and compact each layer before the preceding layer takes initial set such that there is no surface of separation between layers. Do not taper layers of concrete in wedge-shaped slopes but instead place them with reasonably square ends and level tops.

If placing additional concrete against hardened concrete, take care to remove all laitance and to roughen the surfaces of the concrete to ensure that fresh concrete is deposited upon sound concrete surfaces and an acceptable bond is obtained. Thoroughly wet the existing concrete for at least 2 hours before placing additional concrete.

Deposit and compact to form a compact, dense, impervious concrete of uniform texture which shows smooth faces on exposed surfaces. Repair, remove and replace in whole or in part as directed and at no additional cost to the Department, any section of concrete found to be porous, cracked, plastered or otherwise defective.

Protect beams and girders during concreting operations. Remove any concrete that gets on beams or girders immediately by an approved method to restore the surface to the specified condition.

420-5 PUMPING CONCRETE

Placement of concrete by pumping is permitted only when approved. Use and locate suitable pumping equipment that is adequate in capacity for the work and so no vibrations result which might damage freshly placed concrete. Do not use pumping equipment, including the conduit system, which contains any aluminum or aluminum alloy that comes in contact with the concrete.

Waste all grout used to lubricate the inner surfaces of the conduit system.

Pump so a continuous stream of concrete without air pockets is delivered. For test purposes, take concrete from the discharge end of the pump.

420-6 SLUMP TESTS

The slump of the concrete is determined in accordance with AASHTO T 119.

When a slump test is made and the results of the test exceed the specified maximum, a check test is made immediately from the same batch or truck load of concrete. If the average of the 2 test results exceeds the specified maximum slump, the batch or truck load that contains the batch is rejected.

420-7 PLACING CONCRETE IN COLD WEATHER

(A) General

Do not place concrete when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat, is below 35°F without permission. When such permission is granted, uniformly heat the aggregates and water to a temperature not higher than 150°F. Place the concrete when the temperature of the heated concrete is at least 55°F and not more than 80°F.

Use aggregates that are free of ice, frost and frozen particles. Do not place concrete on frozen foundation material.

Protect all concrete with heated enclosures or by insulation whenever any of the following conditions occur:

(1) The concrete is placed when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat, is below 35°F.

(2) The air temperature, measured at the location of the freshly placed concrete in the shade away from artificial heat, is below 35°F and the concrete has not yet attained an age of 72 hours or an age of 48 hours when using high early strength Portland cement concrete. If the mix contains fly ash or ground granulated blast furnace slag, protect the concrete for 7 days.

Provide and place, at directed locations, a sufficient number of maximum-minimum recording thermometers to provide an accurate record of the temperature surrounding the concrete during the entire protection period.

Assume all risks connected with the placing of concrete under the cold weather conditions referred to herein. Permission given to place concrete when the temperature is below 35°F and the subsequent protection of the concrete as required herein does not relieve the Contractor in any way of the responsibility for obtaining the required results.

(B) Heated Enclosures

Immediately enclose Portland cement concrete that is placed when the air temperature is below 35°F and Portland cement concrete that has not yet attained an age of 72 hours. Enclose the cement before the air temperature falls below 35°F with a housing consisting of canvas or other approved material supported by an open framework. Maintain the air surrounding the concrete at a temperature of at least 50°F and no more than 90°F for the remainder of the 72-hour period. Apply these same requirements to high early strength Portland cement concrete except reduce the 72-hour period to 48 hours. Do not begin these time periods until completing manipulation of each separate mass of concrete.

Provide such heating apparatus as stoves, salamanders or steam equipment and the necessary fuel. When using dry heat, provide means of preventing loss of moisture from the concrete.

(C) Insulation

As an alternate to the heated enclosure specified in Subarticle 420-7(B), use insulated forms or insulation meeting all requirements of this subarticle to protect concrete. Use insulation under the same conditions that require heated enclosures. Place the insulation on the concrete as soon as initial set permits.

When using insulation for cold weather protection, batch concrete for sections 12" or less in thickness or diameter as outlined below. Use Type III Portland cement without any increase in cement content, or use Type I or II Portland cement with the cement content increased to 1.80 barrels/cy. When the mix includes fly ash, use a mix containing 572 lb/cy of cement and at least 172 lb/cy of fly ash. When the mix includes ground granulated blast furnace slag, use a mix containing 465 lb/cy of cement and 250 lb/cy of ground granulated blast furnace slag.

Use insulated materials with a minimum thickness of 1". Insulate overhang forms both on the outside vertical faces and on the underside with a 1" minimum thickness of either rigid or blanket type insulation. Use insulating materials which provide a minimum system R value of 4.0 in the up mode as determined by ASTM C1363 with a 15 mph wind over the cold side of the material and a minimum differential of 50°F. Furnish results of tests conducted in accordance with ASTM C1363 by an acceptable commercial testing laboratory for review, comments and acceptance.

Obtain such acceptance before use of the material. Face or cover insulating blankets, top and bottom, with polyethylene or similar waterproofing material meeting Article 1026-3 except for the length and color requirements. Place blankets on the concrete to form a waterproof surface for the protected concrete. Do not use blankets with rips and tears in the waterproofing material unless acceptably repaired. When the anticipated low temperature expected during the protection period is less than 10°F, provide 2" of insulation. Overlap blanket insulation mats at the edges by at least 6". Tightly butt rigid type insulation sheets together and seal. Take particular care to provide effective protection of curbs, corners and around protruding reinforcing steel.

Should the air under the insulation fall below 50°F during the protection period, immediately cover the concrete with canvas and framework or other satisfactory housing and apply heat uniformly at a rate such that the air surrounding the concrete is at least 50°F for the remainder of the protection period.

If insulating materials are removed from the concrete before the expiration of the curing period, cure the concrete for the remainder of the period in accordance with Article 420-15.

420-8 CONSTRUCTION JOINTS

Provide construction joints only where located in the plans or shown in the placing schedule, unless otherwise approved in writing.

Place the concrete in each integral part of the structure continuously. Do not start work on any such part unless the concrete supply, forces and equipment are sufficient to complete the part without interruption in the placing of the concrete.

In case of emergency, make construction joints or remove the concrete as directed.

Make construction joints without keys, except when required in the plans. Rough float surfaces of fresh concrete at horizontal construction joints sufficiently to thoroughly consolidate the concrete at the surface.

After placing concrete to the construction joint and before placing fresh concrete, thoroughly clean the entire surface of horizontal construction joints of surface laitance, curing compound and other materials foreign to the concrete. Clean vertical construction joints of curing compound and other materials foreign to the concrete.

Thoroughly clean and wet concrete surfaces for at least 2 hours before placing additional concrete to help bonding.

420-9 WIDENING EXISTING STRUCTURES

Where plans call for widening existing concrete structures or otherwise require bonding new concrete to old, remove portions of the existing structures as indicated in the plans.

When extending an existing culvert, remove the following portions of the existing culvert: the portions that interfere with the proposed extension, headwalls only as necessary to clear proposed subgrade by at least 18" and wingwalls to square surfaces the full thickness of the new sidewalls. Cut existing wingwall reinforcing steel off flush with the concrete surface.

Thoroughly roughen, clean of loose material and wet connecting surfaces of the old concrete for at least 2 hours before placing new concrete.

420-10 EXPANSION JOINTS

(A) General

Locate and construct all joints as shown in the plans.

Chamfer or edge the edges of joints as shown in the plans or as directed.

Immediately after removing the forms, inspect the expansion joint carefully. Neatly remove any concrete or mortar in the joint.

(B) Filled Joints

Use cork, bituminous fiber, neoprene or rubber in accordance with Article 1028-1 in all expansion joint material. Use an optional second layer to obtain the required thickness, when a thickness of more than 1" is required.

Cut the joint filler to the same shape and size as the area to be covered except cut it 1/2" below any surface that is exposed to view in the finished work. As an option, cut the joint filler the same size and shape as that of the adjoining surfaces and neatly cut back the material 1/2" on the surfaces that are exposed to view after the concrete hardens. Cut the joint filler out of as few pieces as practical and, except as noted above, completely fill the space provided. Fasten the pieces in any one joint together in an approved manner. Do not use loose fitting or open joints between sections of filler or between filler and forms. Do not use joints made up with small strips. Place 2-ply roofing felt over all joints in the filler material in vertical expansion joints below top of curbs. Place the felt on the side of the joint adjacent to the new pour.

In accordance with Article 1028-3, seal all expansion joints with a low modulus silicone sealant.

420-11 DRAINS IN WALLS AND CULVERTS

Construct drain holes and weep holes in abutment walls, wing walls, retaining walls and the exterior walls of culverts as shown in the plans unless otherwise directed and backfill in accordance with Articles 414-7 and 414-8.

Cover drain holes and weep holes at the back face of the wall with hardware cloth of commercial quality, approximately No. 4 wire reinforcement, of aluminum or galvanized steel wire.

420-12 ANCHOR BOLTS AND BEARING AREAS

(A) Anchor Bolts

Accurately set all necessary anchor bolts in piers, abutments or pedestals either while placing concrete, in formed holes or in holes cored or drilled after the concrete sets.

If set in the concrete, position the bolts with templates and rigidly hold in position while placing the concrete.

Form holes by inserting in the fresh concrete oiled wooden plugs, metal pipe sleeves or other approved devices, and withdrawing them after the concrete partially sets. Provide holes formed in this manner that are at least 4" in diameter.

Core holes at least 1" larger in diameter than the bolt used. Use approved equipment for coring concrete. Do not use impact tools. Place reinforcing steel to provide adequate space to core bolt holes without cutting the reinforcing steel.

During freezing conditions, protect anchor bolt holes from water accumulation at all times.

Bond the anchors with a nonshrink Portland cement grout or a grout made with epoxy resin. Completely fill the holes with grout. Use any pre-approved nonshrink composition compatible with the concrete.

(B) Bearing Areas

Finish bridge seat bearing areas to a true level plane to not vary perceptibly from a straightedge placed in any direction across the area.

Place bearing plates in accordance with Article 440-4.

420-13 ADHESIVELY ANCHORED ANCHOR BOLTS OR DOWELS

(A) Description

The work covered by this section consists of furnishing all necessary labor, equipment and materials and performing all operations necessary for installing anchor bolts/dowels in concrete using an adhesive bonding system in accordance with the details shown in the plans and with Article 1081-2.

The use of adhesive anchors for overhead installments is not permitted.

Submit a description of the proposed adhesive bonding system to the Engineer for review, comments and acceptance. Include in the description the bolt type and its deformations, equipment, manufacturer's recommended hole diameter, embedment depth, material specifications and any other material, equipment or procedure not covered by the contract. List the properties of the adhesive, including density, minimum and maximum temperature application, setting time, shelf life, pot life, shear strength and compressive strength. If bars/dowels containing a corrosion protective coating are required, provide an adhesive that does not contain any chemical elements that are detrimental to the coating and include a statement to this effect in the submittal concerning the contents as required by Federal or State laws and regulations.

(B) Procedure

(1) Drilling of Holes into Concrete

When directed, use a jig or fixture to ensure the holes are positioned and aligned correctly during the drilling process. Upon approval, adjusting hole locations to avoid reinforcing steel is permitted.

Drill the holes with a pneumatic drill unless another drilling method is approved. Follow the manufacturer's recommendations regarding the diameter of the drilled hole.

Immediately after completion of drilling, blow all dust and debris out of the holes with oil-free compressed air using a wand extending to the bottom of the hole. Remove all dust from the sides of the holes by brushing the holes with a stiff-bristled brush of a sufficient size and then blow the hole free of dust. Repeat this procedure until the hole is completely clean. Check each hole with a depth gauge to ensure proper embedment depth.

Repair spalled or otherwise damaged concrete using approved methods.

(2) Inspection of Holes

Inspect each hole immediately before placing the adhesive and the anchor bolts/dowels. Ensure all holes are dry and free of dust, dirt, oil and grease. Rework any hole that does not meet the requirements of the contract.

(3) Mixing of Adhesive

Mix the adhesive in strict conformance with the manufacturer's instructions.

(4) Embedment of Anchor Bolt/Dowel

Clean each anchor bolt/dowel so it is free of all rust, grease, oil and other contaminants.

Unless otherwise shown in the plans, the minimum anchor bolt/dowel embedment depth is such that the adhesive develops at least 125% of the anchor bolt/dowel yield load as determined by the manufacturer.

Installation of the adhesive anchors shall be in accordance with manufacturer's recommendations and shall occur when the concrete is above 40°F and has reached its 28 day strength. The anchors shall be installed before the adhesive's initial set (gel time).

Insert the anchor bolt/dowel the specified depth into the hole and slightly agitate it to ensure wetting and complete encapsulation. After insertion of the anchor bolt/dowel, strike off any excessive adhesive flush with the concrete face. Should the adhesive fail to fill the hole, add additional adhesive to the hole to allow a flush strike-off. Do not disturb the anchor bolts/dowels while adhesive is hardening.

(C) Field Testing

When specified in the plans, test the installed anchor bolts/dowels for adequate adhesive as specified below. Inform the Engineer when the tests will be performed at least 2 days before testing. Conduct the tests in the presence of the Engineer.

Use a calibrated hydraulic centerhole jack system for testing. Place the jack on a plate washer that has a hole at least 1/8" larger than the hole drilled into the concrete. Position the plate washer on center to allow an unobstructed pull. Position the anchor bolts/dowels and the jack on the same axis. Ensure an approved testing agency calibrates the jack within 6 months before testing. Supply the Engineer with a certificate of calibration.

In the presence of the Engineer, field test the anchor bolt or dowel in accordance with the test level shown in the plans and the following:

(1) Level 1 Field Testing

Test at least 1 anchor but at least 10% of all anchors to 50% of the yield load shown in the plans. If less than 60 anchors are to be installed, install and test the required number of anchors before installing the remaining anchors. If more than 60 anchors are to be installed, test the first 6 anchors before installing the remaining anchors, then test 10% of the number in excess of 60 anchors.

(2) Level 2 Field Testing

Test at least 2 anchors but at least 10% of the all anchors to 80% of the yield load shown in the plans. If less than 60 anchors are to be installed, install and test the required number of anchors before installing the remaining anchors. If more than 60 anchors are to be installed, test the first 6 anchors before installing the remaining anchors, then test 10% of the number in excess of 60 anchors.

Testing should begin only after the manufacturer's recommended cure time has been reached. For testing, apply and hold the test load for 3 minutes. If the jack experiences any drop in gauge reading, the test shall be restarted. For the anchor to be deemed satisfactory, the test load shall be held for 3 minutes with no movement or drop in gauge reading.

Record data for each anchor bolt or dowel tested on the report form entitled Installation Test Report of Adhesively Anchored Anchor Bolts or Dowels. Obtain this form from the Department's Materials and Tests Engineer. Submit a copy of the completed report forms to the Engineer.

Final acceptance of the adhesively anchored system is based on the conformance of the pull test. Failure to meet the criteria of this specification is grounds for rejection.

Remove all anchors or dowels that fail the field test without damage to the surrounding concrete. Redrill holes to remove adhesive bonding material residue and clean the hole in accordance with specifications. For reinstalling replacement anchors or dowels, follow the same procedures as new installations. Do not reuse failed anchors or dowels unless approved by the Engineer.

420-14 PLACING AND FINISHING BRIDGE DECKS

(A) Placing Concrete

Unless otherwise noted in the plans, use Class AA cast-in-place concrete conforming to Section 1000. When noted in the plans, use sand lightweight concrete conforming to Section 1000.

Place concrete in accordance with these specifications. Properly vibrate concrete to avoid honeycomb and voids. Ensure pouring sequences, procedures and mixes are approved by the Engineer.

For metal stay-in-place forms, do not place concrete on the forms to a depth greater than 12" above the top of the forms. Do not drop concrete more than 3 ft above the top of the forms, beams or girder. Keep the top surface of prestressed concrete panels clean. Thoroughly inspect panels and remove any foreign matter, oil, grease or other contaminants either with a high pressure water blast or sand blast. Saturate the top surface of the prestressed concrete panels by thoroughly wetting the top surface with water for at least 2 hours before placing the cast-in-place concrete slab. Do not allow the wetted panel surface to dry and remove all puddles and ponds of water from the surface of the panels and top of girder flanges before placing the cast-in-place concrete slab.

Obtain a smooth riding surface of uniform texture, true to the required grade and cross section, on all bridge decks.

Do not place bridge deck concrete until the Engineer is satisfied that adequate personnel and equipment are present to deliver, place, spread, finish and cure the concrete within the scheduled time; that experienced finishing machine operators and concrete finishers are employed to finish the deck; and that weather protective equipment and all necessary finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. Between April 15 and October 15, begin placing the bridge deck concrete as early as practical to allow the work to be accomplished during the cooler hours when forms, beams and reinforcing steel are at ambient air temperatures.

Unless otherwise permitted, set the rate of concrete placement and use a set retarder such that the concrete remains workable until the entire operation of placing, screeding, rescreeding, surface testing and corrective measures where necessary are complete. Use of a set retarder is waived when conditions clearly indicate it is not needed.

Place concrete in the deck when the concrete temperature at the time of placement is at least 50°F and no more than 90°F, except where other temperatures are required by Article 420-7.

Place concrete at a minimum rate of 35 cy/hr.

Place and firmly secure supports for screeds or finishing machines before beginning placement of concrete. Set supports to elevations necessary to obtain a bridge roadway floor true to the required grade and cross section, and make allowance for anticipated settlement. Use supports of a type that upon installation, no springing or deflection occurs under the weight of the finishing equipment. Locate the supports such that finishing equipment operates without interruption over the entire bridge deck.

Immediately before placing bridge deck concrete, check all falsework and make all necessary adjustments. Provide suitable means such as telltales to permit ready measurement by the Engineer of deflection as it occurs. Unless otherwise permitted, do not adjust the profile grade-line for any of the forming types used.

On continuous steel beam or girder spans, cast the concrete in the order shown in the plans. Place concrete in a continuous manner between headers. Use approved screeds, screed supports and screeding methods.

(B) Finishing

Unless otherwise specified or permitted, use mechanically operated longitudinal or transverse screeds for finishing bridge deck concrete. Do not use vibratory screeds unless specifically approved. Use readily adjustable screeds with sufficient rigidity and width to strike-off the concrete surface at the required grade. Do not use aluminum strike-off elements of screeds and hand tools used for finishing concrete.

Furnish personnel and equipment necessary to verify the screed adjustment and operation before beginning concrete placement.

Unless otherwise permitted, do not use longitudinal screeds for pours greater than 85 ft in length. Place sufficient concrete ahead of the screeded area to assure all dead load deflection occurs before final screeding.

When using a transverse screed on a span with a skew angle less than 75° or more than 105°, orient and operate the truss or beam supporting the strike-off mechanism parallel to the skew. Position the strike-off parallel to the centerline of bridge and make the leading edge of concrete placement parallel to the skew. If approved, operate at a reduced skew angle on very wide or heavily skewed spans where the distance between screed supports exceeds 100 ft.

Orient and operate transverse screeds used on spans with skew angles between 75° and 105° parallel to the skew or perpendicular to the centerline of bridge. Position the strike-off parallel to the centerline of bridge. Before placing concrete, verify the adjustment and operation of the screed as directed by operating the screed over the entire area and across all end bulkheads. Check the floor thickness and cover over reinforcing steel shown in the plans and make adjustments as necessary.

During the screeding operation, keep an adequate supply of concrete ahead of the screed and maintain a slight excess immediately in front of the screed. Operate the screed to obtain a substantially uniform surface finish over the entire bridge deck. Do not allow workmen to walk on the concrete after screeding. Use at least 2 approved work bridges to provide adequate access to the work for finishing, testing, straightedging, making corrections, fogging, applying curing medium and for other operations requiring access to the bridge deck. Support the work bridges outside the limits of concrete placement.

The Engineer will take random depth checks of deck thickness and cover over reinforcing steel over the entire placement area and directly behind the screed in the fresh concrete. If depth checks indicate variations from plan dimensions in excess of 1/2", take corrective action immediately.

Immediately following the screed and while the concrete is still workable, test the floor surface for irregularities with a 10 ft straightedge. Test by holding the straightedge in successive positions parallel to the centerline of bridge and in contact with the floor surface. Test the surface approximately 18" from the curb line, at the centerline of each lane and at the centerline of 2 lane bridges. Advance along the bridge in stages of not more than half the length of straightedge. Test the surface transversely at the ends, quarter points and center of the span as well as other locations as directed.

Immediately correct areas showing depressions or high spots of more than 1/8" in 10 ft by filling depressions with fresh concrete or by striking off high spots. Make corrections with hand tools or a combination of hand tools and rescreeding. Do not use the straightedge as a finishing tool. Give surfaces adjacent to expansion joints special attention to assure they meet the required smoothness.

Provide on site fogging equipment which is capable of applying water to the concrete in the form of a fine fog mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the bridge deck resulting from wind, high temperature, low humidity or a combination of these factors. Do not apply the moisture from the nozzle under pressure directly upon the concrete and do not allow it to accumulate on the surface in a quantity sufficient to cause a flow or wash the surface. Maintain responsibility for determining when to apply the fog mist but apply it when directed.

Keep readily available on site an adequate supply of suitable coverings that will protect the surface of the freshly placed bridge deck from rain. After the water sheen disappears from the surface and before the concrete becomes non-plastic, finish the surface of the floor further by burlap dragging, fine bristle brooming, belting or other acceptable method which produces an acceptable uniform texture.

Do not use membrane curing compound unless approved. Cure the concrete using the water method in accordance with Subarticle 420-15(B), with the following exceptions. Before reaching initial set, place a curing medium consisting of burlap under polyethylene sheets or another approved material on the deck and keep moist for at least 7 curing days. Wet the burlap or other approved curing medium before placing on the deck. Apply water to the curing medium through soaker hoses or another approved method. Apply water in amounts to keep the medium moist but do not allow the water to flow or pond on the deck.

After curing the concrete, test the finished surface with an approved rolling straightedge designed, constructed and adjusted to accurately indicate or mark all floor areas which deviate from a plane surface by more than 1/8" in 10 ft. Remove all high areas in the hardened surface in excess of 1/8" in 10 ft with an approved grinding or cutting machine. Where variations are such that the corrections will extend below the limits of the top layer of grout, seal the corrected surface with an approved sealing agent as required. If approved, correct low areas in an acceptable manner. Produce corrected areas that have a rough, uniform texture and present neat patterns. In all cases, maintain at least 2" of concrete cover over reinforcement.

Unless otherwise indicated in the plans, groove bridge decks. Produce grooves perpendicular to the centerline of bridge. Do not start grooving until final straightedging and, when necessary, acceptable corrective measures are complete. Cut grooves into the hardened concrete using a mechanical saw device, which leaves rectangular grooves 1/8" wide and 3/16" deep. Produce grooves that have a center to center spacing of 3/4". Do not groove the deck surface within 18" of the gutter lines and 2" of expansion joints or elastomeric concrete in expansion joint blockouts. On skewed bridges, ungrooved triangular areas adjacent to the joint are permitted, provided the distance from the centerline joint to the nearest groove, as measured parallel to the centerline of roadway, does not exceed 18". Between expansion joints on horizontally curved bridges, periodically adjust the grooving operation such that adjacent grooves are separated by no more than 3" along the outer radius of the bridgedeck.

Continuously remove all slurry or other residue resulting from the grooving operation from the bridge deck by vacuum pick-up or other approved methods. Prevent slurry from flowing into deck drains or onto the ground or body of water under the bridge. Dispose of all residue off the project.

(C) Inspection

The Engineer observes all phases of the construction of the bridge deck slab. These phases include installation of the metal forms; location and fastening of the reinforcement; composition of concrete items; mixing procedures, concrete placement and vibration; and finishing of the bridge deck.

After the deck concrete is in place for a minimum period of 2 days, test the concrete for soundness and bonding of the metal stay-in-place forms by sounding with a hammer as directed. For at least 50% of the individual form panels, as selected by the Engineer, hammer test over the entire area of the panel. If areas of doubtful soundness are disclosed by this procedure, remove the forms from such areas for visual inspection after the pour attains a minimum compressive strength of 2,400 psi. Remove the stay-in-place forms.

At locations where sections of the forms are removed, do not replace the forms, but repair the adjacent metal forms and supports to present a neat appearance and assure their satisfactory retention. As soon as the forms are removed, allow the Engineer to examine for cavities, honeycombing and other defects. If irregularities are found, and in the opinion of the Engineer these irregularities do not justify rejection of the work, repair the concrete as directed. If the concrete where the forms are removed is unsatisfactory, remove additional forms, as necessary, to inspect and repair the slab. Modify the methods of construction as required to obtain satisfactory concrete in the slabs. Remove and repair all unsatisfactory concrete as directed.

Provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedures.

420-15 CURING CONCRETE

(A) General

Unless otherwise specified in the contract, use any of the following methods except for membrane curing compounds on bridge deck and approach slab, or on concrete which is to receive epoxy protective coating in accordance with Article 420-18. Advise the Engineer before using the proposed method. Ensure all material, equipment and labor necessary to promptly apply the curing are on the site before placing any concrete. Cure all patches in accordance with this article. Improperly cured concrete is considered defective.

Define "curing temperature" as the atmospheric temperature taken in the shade away from artificial heat, with the exception that it is the temperature surrounding the concrete where the concrete is protected in accordance with Article 420-7.

Define a "curing day" as any consecutive 24-hour period, beginning when the manipulation of each separate mass is complete, during which the air temperature adjacent to the mass does not fall below 40°F.

After placing the concrete, cure it for 7 full curing days.

Take all reasonable precautions to prevent plastic shrinkage cracking of the concrete, including the provision of wind screens, fogging, application of an approved temporary liquid moisture barrier or the early application of temporary wet coverings to minimize moisture loss.

Repair, remove or replace as directed concrete containing plastic shrinkage cracks.

(B) Water Method

Keep the concrete continuously wet by the application of water, through soaker hoses or another approved method, for a minimum period of 7 curing days after placing the concrete.

When using cotton mats, rugs, carpets, earth blankets or sand blankets to retain the moisture, keep the entire surface of the concrete damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed, until the surface of the concrete is covered with the curing medium. Do not apply the moisture from the nozzle under pressure directly upon the concrete and do not allow it to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface. At the expiration of the curing period, clear the concrete surfaces of all curing mediums.

(C) Membrane Curing Compound Method

Spray the entire surface of the concrete uniformly with a wax-free, resin-base curing compound conforming to Article 1026-2. Use clear curing compound to which a fugitive dye is added for color contrast on bridge superstructures, substructures and retaining walls. Use either white pigmented or clear curing compound on culverts.

Apply the membrane curing compound after the surface finishing is complete and immediately after the free surface moisture disappears. During the finishing period, protect the concrete by applying water with the fogging equipment specified in Subarticle 420-15(B).

Seal the surface with a single uniform coating of the specified type of curing compound applied at the rate of coverage recommended by the manufacturer or as directed, but at least one gallon per 150 sf of surface area.

At the time of use, thoroughly mix the compound with the pigment uniformly dispersed throughout the vehicle. If the application of the compound does not result in satisfactory coverage, stop the method and begin water curing, as set out above, until the cause of the defective work is corrected.

At locations where the coating shows discontinuities, pinholes or other defects, or if rain falls on the newly coated surface before the film dries sufficiently to resist damage, apply an additional coat of the compound at the same rate specified herein immediately after the rain stops.

Completely remove any curing compound adhering to a surface to which new concrete is to be bonded by sandblasting, steel wire brushes, bush hammers or other approved means.

Protect the concrete surfaces to which the compound is applied from abrasion or other damage that results in perforation of the membrane film for 7 curing days after placing the concrete. If the film of membrane compound is damaged or removed before the expiration of 7 curing days, immediately cure the exposed concrete by the water method until the expiration of the 7 curing days or until applying additional curing compound.

If the application of curing compound is delayed, immediately start applying water as provided in Subarticle 420-15(B) and continue until resuming or starting application of the compound.

(D) Polyethylene Sheeting Method

Wet the exposed finished surface of concrete with water, using a nozzle that so atomizes the flow to form a mist and not a spray, until the concrete sets, after which place the white opaque polyethylene sheeting. Continue curing for 7 curing days after the concrete is placed. If the sheeting is damaged or removed before the expiration of 7 curing days, immediately cure the exposed concrete by the water method until placing additional sheeting or until after 7 curing days.

Use sheeting which provides a complete continuous cover of the entire concrete surface. Lap the sheets at least 12" and securely weigh down or cement them together to provide a waterproof joint.

If any portion of the sheets is broken or damaged before the expiration of the curing period, immediately repair the broken or damaged portions with new sheets properly secured in place.

Do not use sections of sheeting damaged to such an extent as to render them unfit for curing the concrete.

(E) Forms-in-Place Method

As an option, cure surfaces of concrete by retaining the forms in place for at least 7 curing days after placing the concrete.

If electing to leave forms in place for a part of the curing period and using one of the other methods of curing included in this article for the remainder of the curing period, keep the concrete surfaces wet during transition between curing methods.

420-16 REMOVAL OF FORMS AND FALSEWORK

Do not remove forms and falsework for the portions of structures listed in Table 420-1 until the concrete attains the compressive strength shown, as evidenced by approved, nondestructive test methods or by conducting compressive strength tests in accordance with AASHTO T 22 and T 23. Furnish approved equipment used for nondestructive tests.

TABLE 420-1
MINIMUM CONCRETE STRENGTH
FOR REMOVAL OF FORMS AND FALSEWORK

Portion of Structure	Minimum Compressive Strength, psi
Bridge Deck Slabs and overhangs for beam and girder bridges	3,000
Arch culverts, top slabs of box culverts, walls of box culverts when cast monolithically with the top slab or when the wall is 10 ft or more in height, caps and struts of substructures, diaphragms and other members subject to dead load bending	2,400

Remove forms for ornamental work, railing, parapets, walls less than 10 ft in height, curb faces on bridge superstructures and vertical surfaces that do not carry loads, any time after 3 hours if the concrete is set sufficiently to permit form removal without damage to the member.

Do not remove forms used for insulation before the expiration of the minimum protective period required in Article 420-7.

Do not remove formwork for bent diaphragms until after casting deck concrete and allowing the concrete to attain a strength of 2,400 psi. As an option, to remove support from bent diaphragms before casting deck concrete, submit for approval a method to prevent the possibility of bent diaphragms slipping downward.

When removing forms before the end of the required curing period, use other curing methods to complete the required curing. When removing forms from underneath slabs before the end of the curing period, complete the curing in accordance with Subarticle 420-15(C).

420-17 SURFACE FINISH

(A) General

Finish all concrete as required by this article except for bridge decks. Use the type of finish called for in Subarticles 420-17(B) through 420-17(D), except where the contract requires a Class 1 or Class 2 surface finish. Apply epoxy protective coating as required by Article 420-18.

(B) Ordinary Surface Finish

Apply ordinary surface finish to all formed concrete surfaces either as a final finish or preparatory to a higher class finish. On surfaces backfilled or otherwise covered, or enclosed surfaces, the removal of fins and form marks, the rubbing of grouted areas to a uniform color, and the removal of stains and discoloration, is not required. Use an ordinary surface finish, unless otherwise required, as final finish on all surfaces.

During the placing of concrete, take care to use methods of compaction that result in a surface of even texture free from voids, water or air pockets, and that the coarse aggregate is forced away from the forms to leave a mortar surface.

Immediately after removing the forms, clean and fill with grout all pockets, depressions, honeycombs and other defects as directed. Remove all form ties or metal spacers to a depth of at least 1" below the surface of the concrete then clean and fill the resulting holes or depressions with grout. As an option, break off flush with the concrete surface those metal devices with exposed cross-sectional area not exceeding 0.05 sq.in. on surfaces permanently in contact with earth fill. Unless otherwise required, remove fins and other projections flush with the concrete surface. Remove stains and discoloration.

Use grout for patching which contains cement and fine aggregate from the same sources and in the same proportions as used in the concrete. Cure the grout in accordance with Article 420-15. After the grout has thoroughly hardened, rub the surface with a carborundum stone as required to match the texture and color of the adjacent concrete.

Obtain the final finish for railing in one of the following ways:

(1) Brush Finish

After striking off the concrete as described above, have skilled and experienced concrete finishers thoroughly work and float the surface with a wooden, canvas or cork float. Before this last finish sets, lightly stroke the surface with a fine brush to remove the surface cement film, leaving a fine grained, smooth, but sanded texture.

(2) Float Finish

Finish the surface with a rough carpet float or other suitable device leaving the surface even, but distinctly sandy or pebbled in texture.

(C) Unformed Surfaces Not Subjected to Wear

Finish all unformed surfaces not subjected to wear by placing an excess of material in the forms and removing or striking off such excess with a wooden template, forcing the coarse aggregate below the mortar surface. Do not use mortar topping for concrete railing caps and other surfaces falling under this classification.

(D) Sidewalk, Islands or Stairways on Bridges

Strike off and compact fresh concrete until a layer of mortar is brought to the surface. Finish the surface to grade and cross section with a float, trowel smooth and finish with a broom. If water is necessary, apply it to the surface immediately before brooming. Broom transverse to the line of traffic.

(E) Class 1 Surface Finish

In addition to Subarticle 420-17(B), as soon as the pointing sets sufficiently to permit, thoroughly wet the entire surface with a brush and rub with a coarse carborundum stone or other equally good abrasive, bringing the surface to a paste. Continue rubbing to remove all form marks and projections, producing a smooth dense surface without pits or irregularities.

Carefully spread or brush uniformly over the entire surface the material ground to a paste by rubbing and allowing it to take a reset. After rubbing, cure the surface for 7 curing days. Obtain the final finish by thoroughly rubbing with a fine carborundum stone or other equally good abrasive. Continue this rubbing until the entire surface is of a smooth texture and uniform color.

(F) Class 2 Surface Finish

In addition to Subarticle 420-17(B), after the pointing sets sufficiently to permit, thoroughly wet and rub the entire surface with a coarse carborundum stone or other equally good abrasive to bring the surface to a smooth texture and remove all form marks. Finish the paste formed by rubbing as described above by carefully stroking with a clean brush, or spread it uniformly over the surface and allow it to take a reset, then finish it by floating with a canvas, carpet-faced or cork float; or rub down with dry burlap.

420-18 EPOXY COATING

(A) General

Use a Type 4A flexible and moisture insensitive epoxy coating in accordance with Section 1081. Provide a Type 3 material certification in accordance with Article 106-3 showing the proposed epoxy meets Type 4A requirements.

(B) Surfaces

Apply the epoxy protective coating to the top surface area, including chamfer area of bent caps under expansion joints and of end bent caps, excluding areas under elastomeric bearings. For cored slab and box beam bridges, do not apply the epoxy protective coating to the bent or end bent caps.

Use extreme care to keep the area under the elastomeric bearings free of the epoxy protective coating. Thoroughly clean all dust, dirt, grease, oil, laitance and other objectionable material from the concrete surfaces to be coated. Air blast all surfaces immediately before applying the protective coating.

Use only cleaning agents preapproved by the Engineer.

(C) Application

Apply epoxy protective coating only when the air temperature is at least 40°F and rising, but less than 95°F and the surface temperature of the area to be coated is at least 40°F. Remove any excess or free standing water from the surfaces before applying the coating. Apply one coat of epoxy protective coating at a rate such that it covers between 100 and 200 sf/gal.

Under certain combinations of circumstances, the cured epoxy protective coating may develop an oily condition on the surface due to amine blush. This condition is not detrimental to the applied system.

Apply the coating so the entire designated surface of the concrete is covered and all pores are filled. To provide a uniform appearance, use the exact same material on all visible surfaces.

420-19 PROTECTION OF SUBSTRUCTURE CONCRETE FROM RUST STAINS

To prevent unpainted structural steel from staining substructure concrete, protect all final exposed areas of the concrete from rust stains until casting the bridge deck and sealing the expansion joints. Use an approved method for protecting the concrete.

Instead of the above, remove the stains by approved methods and cleaning agents.

420-20 PLACING LOAD ON STRUCTURE MEMBERS

Do not place beams or girders on concrete substructures until the concrete in the substructure develops a minimum compressive strength of 2,400 psi.

In addition to Article 410-8, do not place backfill or fill for retaining walls, abutments, piers, wing walls or other structures that will retain material to an elevation higher on one side than the other until the concrete develops the minimum specified strength for the class of concrete required for the structure.

Do not carry backfill for arch culverts and box culverts to an elevation higher than one foot above the top of footing or bottom slab until the concrete develops the minimum specified strength for the class of concrete required for the culvert.

Adhere to the following time and strength requirements for erection of forms and construction of superimposed bridge substructure elements:

(A) Wait at least 12 hours between placing footing or Drilled Pier concrete and erecting column forms.

(B) Wait at least 24 hours between placing footing or Drilled Pier concrete and placing column concrete.

(C) Wait at least 72 hours between placing column concrete and beginning erection of cap forms or until column concrete attains a compressive strength of at least 1,500 psi.

(D) Wait at least 96 hours between placing column concrete and placing cap concrete or until column concrete attains a compressive strength of at least 2,000 psi.

Do not place vehicles or construction equipment on a bridge deck until the deck concrete develops the minimum specified 28 day compressive strength and attains an age of at least 14 curing days. The screed may be rolled across a previously cast bridge deck if the entire pour has not achieved initial set. If any portion of the deck concrete has achieved initial set, the screed cannot be rolled across the bridge deck until the concrete develops a compressive strength of at least 1,500 psi. Construction equipment is allowed on bridge approach slabs after the slab concrete develops a compressive strength of at least 3,000 psi and attains an age of at least 7 curing days. See Subarticle 420-15(A) for the definition of "curing day."

Provide evidence that the minimum compressive strengths referred to above are satisfied by nondestructive test methods approved in writing or by compressive strength tests made in accordance with AASHTO T 22 and T 23. Furnish approved equipment for use in nondestructive tests.

Do not place construction equipment, materials or other construction loads on any part of the structure without permission. Submit 7 copies of the proposed plans for placing construction loads on the structure for review, comments and acceptance.

Do not abruptly start or stop concrete trucks on bridge deck. Do not mix concrete in the truck while on the deck. While machine forming concrete barrier rail or parapet, do not place any equipment on the deck except one concrete truck and the equipment necessary to place the concrete. Allow concrete barrier rail and parapet to attain a compressive strength of 3,000 psi before placing any traffic on the deck other than equipment referenced above necessary to construct any remaining barrier rail or parapet. Do not operate heavy equipment over any box culvert until properly backfilling with a minimum cover of 3 ft.

420-21 MEASUREMENT AND PAYMENT

Class ____ Concrete will be measured and paid as the number of cubic yards of each class that is incorporated into the completed and accepted structure except as indicated below. The number of cubic yards of concrete is computed from the dimensions shown in the plans or from revised dimensions authorized by the Engineer. When the foundation material is rock, the number of cubic yards of footing concrete is computed by the average end area method

using the lower limits established for foundation excavation. The volume of concrete displaced by piles other than steel piles is not included in the quantity to be paid.

Grooving Bridge Floors will be measured and be paid as the actual number of square feet shown in the plans. Where the plans are revised, the quantity to be paid is the quantity shown on the revised plans.

Reinforced Concrete Deck Slab and Reinforced Concrete Deck Slab (*Sand Lightweight Concrete*) will be measured and paid as the number of square feet shown in the plans. No separate payment will be made for furnishing and incorporating calcium nitrite corrosion inhibitor when required by the plans.

The plan quantity is determined from the horizontal surface area using the nominal dimensions and configuration shown in the Layout Sketch for computing surface area as shown in the plans. Measure the transverse dimension out to the slab including raised median and sidewalk sections. Consider diaphragms a portion of the slab. When required by the plans, consider curtain walls, raised medians, sidewalks, pavement brackets, end posts, sign mounts, luminaire brackets and any other concrete appurtenances or expansion joint material a portion of the slab. Concrete barrier rail (including curved end blocks for the concrete barrier rail, when used) is not considered a portion of the slab.

For structural steel spans, the quantities of concrete and reinforcing steel shown in the plans are based on a metal stay-in-place forming method. These quantities include amounts for 1" additional concrete due to the corrugation of the metal forms, concrete diaphragms and, when required by the plans, curtain walls, pavement brackets, end posts, raised medians, sidewalks and other required attachments based on the profile grade and plan camber of the girders.

For prestressed concrete girder spans, the quantities of concrete and reinforcing steel shown in the plans are based on the forming method detailed in the plans. These quantities include concrete diaphragms, and, when required by the plans, curtain walls, pavement brackets, end posts, raised medians, sidewalks and other required attachments based on the profile grade and plan camber of girders. The quantities include either cast-in-place slab concrete when the plans are detailed for the prestressed concrete panel forming method or amounts for 1" additional concrete due to the corrugation of the metal forms when the plans are detailed for the fabricated metal stay-in-place form forming method and based on the profile grade and plan camber of the girders.

No measurement will be made for concrete or reinforcing steel due to a variation in camber of the girders from the plan camber or for additional quantities required by optional methods of forming.

No separate measurement or payment will be made for furnishing, installing and testing anchor bolts or dowels. Payment at the contract unit prices for the various pay items will be full compensation for all materials, equipment, tools, labor and incidentals necessary to complete the work.

These prices and payments will be full compensation for all items required to construct concrete structures. Remove forms and repair, remove or replace, as directed, concrete containing plastic shrinkage cracks or other defects at no cost to the Department.

Payment will be made under:

Pay Item	**Pay Unit**
Class ____ Concrete	Cubic Yard
Grooving Bridge Floors	Square Foot
Reinforced Concrete Deck Slab	Square Foot
Reinforced Concrete Deck Slab (Sand Lightweight Concrete)	Square Foot